CONFIGURATION FOR IMPLEMENTING ENHANCED VSB ON THE STUDIO SIDE

[0001] This application claims the benefit of the filing date of provisional U.S. patent application serial no. 60/423,616 filed November 4, 2002.

TECHNICAL FIELD OF THE INVENTION

[0002] The present invention relates generally to digital video broadcast and, more particularly, backwards compatible enhanced digital video broadcast.

BACKGROUND OF THE INVENTION

[0003] Various proposals have been made for backwards-compatible enhancements to the vestigial sideband (VSB) modulation digital video broadcast standards promulgated by the Advanced Television Standards Committee (ATSC). One such proposal allows transmission of robustly coded information multiplexed with standard VSB information. FIGURE 4 is a simplified high-level block diagram of the proposed system. The transmission system 400 includes data inputs 401a and 401b receiving the normal and robust data, respectively. The received normal and robust data are switched by multiplexer 402 under the control of control unit 403 based on a field sync signal, then randomized by a conventional VSB data randomizer 404. The randomized data stream is then Reed-Solomon coded by coder 405, and the coded data is processed into packets and interleaved by packet formatter 406 and interleaver 407, after which the interleaved data is trellis coded by encoder 408, also controlled by control unit 403.

[0004] A parity byte generator 409 operates in conjunction with trellis encoder 408 to generate parity data for interleaver 407. The encoded data from trellis encoder 408 is switched by multiplexer 410 with field sync and segment sync signals received on synchronization inputs 411a and 411b, respectively. The resulting data is combined with a pilot signal, modulated and up-converted by signal transmission module 412 and transmitted from antenna 413 over the satellite or terrestrial transmission channel.

[0005] System 400 requires adaptation of the encoder at the transmitter side. If the enhancements proposed could be implemented on the studio side, the encoder at the transmitter side could remain an existing VSB encoder, with only minor changes. There is, therefore, a need in the art for enhancing VSB transmission systems to allow multiplexing of standard and robust data while utilizing an existing encoder on the transmitter side.

SUMMARY OF THE INVENTION

[0006] To address the above-discussed deficiencies of the prior art, it is a primary object of the present invention to provide, for use in a wireless digital video broadcast or other transmission system, enhancements allowing multiplexing of normal and robust data using vestigial sideband modulation that are implemented as an enhanced vestigial sideband encoder on the studio side and a standard vestigial sideband modulator at the transmitter. The enhanced encoder conventionally processes multiplexed data into encoded packets, with backwards compatible parity data supplied for normal data, then deinterleaves the processed data, removes a trailing portion from each packet, and derandomizes the remainder before forwarding the processed encoded data as MPEG compliant packets to the standard modulator for VSB modulation and transmission. Other technical advantages will be readily apparent to one skilled in the art from the following figures, description, and claims.

[0007] Before undertaking the DETAILED DESCRIPTION OF THE INVENTION below, it may be advantageous to set forth definitions of certain words or phrases used throughout this patent document: the terms "include" and "comprise," as well as derivatives thereof, mean inclusion without limitation; the term "or" is inclusive, meaning and/or; the phrases "associated with" and "associated therewith," as well as derivatives thereof, may mean to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, or the like; and the term "controller" means any device, system or part thereof that controls at least one operation, whether such a device is implemented in hardware, firmware, software or some combination of at least two of the same. It should be noted that the functionality associated with any particular controller may be centralized or distributed, whether locally or remotely. Definitions for certain words and phrases are provided throughout this patent document, and those of ordinary skill in the art will understand that such definitions apply in many, if not most, instances to prior as well as future uses of such defined words and phrases.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, wherein like numbers designate like objects, and in which:

[0009] FIGURE 1 a system for enhanced vestigial sideband transmission according to one embodiment of the present invention;

[0010] FIGURE 2 depicts in greater detail a post-processor for use in enhanced vestigial sideband transmission according to one embodiment of the present invention;

[0011] FIGURE 3 is a high level flowchart illustrating a process of backwards compatible multiplexed normal and robust digital video data processing for transmission using a standard vestigial sideband modulator according to one embodiment of the present invention; and

[0012] FIGURE 4 depicts a proposed enhancement to vestigial sideband decoding permitting multiplexing normal and robust data.

DETAILED DESCRIPTION OF THE INVENTION

[0013] FIGURES 1 through 3, discussed below, and the various embodiments used to describe the principles of the present invention in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the invention. Those skilled in the art will understand that the principles of the present invention may be implemented in any suitably arranged device.

[0014] FIGURE 1 depicts a system for enhanced vestigial sideband transmission according to one embodiment of the present invention. Transmission system 100 includes two basic components: an enhanced VSB encoder 101 and a standard VSB encoder/modulator 102. The enhanced VSB encoder 101, which is implemented on the studio side, includes data inputs 103a and 103b receiving the normal and robust data, respectively. The received normal and robust data are switched by multiplexer 104 under the control of control unit 105 based on the field sync signal, then randomized by data randomizer 106. The randomized data stream is then Reed-Solomon (RS) coded by RS encoder 107, and the coded data is processed into packets and interleaved by packet formatter 108 and interleaver 109. The interleaved data is trellis coded by encoder 110, also controlled by control unit 105. Parity byte generator 111 operates in conjunction with trellis encoder 110 to generate parity information for use by interleaver 109.

[0015] Transmission system 100 includes a post-processor 112 receiving the trellis coded data for further processing as described in further detail below. The output of post-processor 112 is Motion Pictures Expert Group (MPEG) compliant packets transmitted at approximately 19.3 mega-bits per second (Mb/s) over any convenient link 113, such as a Studio-to-Transmitter Link (STL), to standard VSB encoder 102 implemented at the transmitter.

[0016] Within standard VSB encoder 102, received packets are sequentially processed by data randomizer 114, RS encoder 115, interleaver 116, and trellis encoder 117. The trellis-encoded data is switched by multiplexer 118 with the field sync and segment sync signals received on synchronization inputs 119a and 119b, respectively, with the resulting multiplexed data combined with a pilot signal, modulated, and up-converted to the radio frequency (RF) by signal transmission module 120 and then transmitted from antenna 121 over a wireless communications channel to a receiver (not shown).

[0017] The processing from multiplexer 104 through trellis encoder 110 in transmission system 100 is identical to the corresponding processing performed in system 400 of

FIGURE 4. Similarly, the processing performed by standard VSB encoder/modulator 102 is identical to conventional processing performed in accordance with the ATSC VSB standard. However, minor modification of the overall processing is required. Specifically, the trellis encoders 110 and 117, the data randomizer 114 within the standard VSB encoder 102, and the main interleaver 109 and 116 in both encoders 101 and 102 need to be synchronized. In addition, parameter signaling data needs to be inserted in the reserved bits of the field sync signal, and the parameter bits and synchronization information need to be transmitted from the studio to the transmitter via some convenient link.

[0018] FIGURE 2 depicts in greater detail a post-processor for use in enhanced vestigial sideband transmission according to one embodiment of the present invention. Post-processor 112 converts trellis encoded data into MPEG-2 compliant packets on the studio side. Post-processor 112, receives the bit X1, X2 output by trellis encoder 110 with the enhanced VSB encoder 101. The processing performed by post-processor 112 is similar to the forward error correction (FEC) or backend portion of a standard VSB decoder, with some modification. Specifically, the post-processor 112 does not include a trellis decoder or Reed Solomon decoder. However, post-processor 112 includes all remaining blocks of a standard VSB decoder, including a bit-to-byte converter and trellis deinterleaver 200 converting the output bits X1, X2 from trellis encoder 110 into bytes and deinterleaving and a (main) deinterleaver 201 performing standard deinterleaving on the data stream, as well as a de-randomizer 202.

[0019] The output of deinterleaver 201 contains 207 bytes per packet. Accordingly, unit 203 within post-processor 112 removes the 20 trailing bytes of each packet to obtain 187 bytes. For the normal data stream packets, the 20 removed bytes correspond to Reed Solomon parity bytes. For the robust data stream packets, the 20 removed bytes contain actual encoded data. However, the removed 20 bytes of the encoded robust data stream packets is recovered by the Reed Solomon encoder on the transmitter side.

[0020] The 187 byte packets are de-randomized by a standard de-randomizer 202. Before transmission, an MPEG sync byte may be inserted to obtain 188 byte packets, using synchronization identical to that with a standard VSB backend unit.

[0021] FIGURE 3 is a high level flowchart illustrating a process of backwards compatible multiplexed normal and robust digital video data processing for transmission using a standard vestigial sideband modulator according to one embodiment of the

present invention. The process 300 begins with initiation of multiplexed normal and robust digital video data transmission (step 301) utilizing an enhanced VSB encoder implemented at a studio. Normal and robust digital video data is multiplexed (step 302), alternately switching (from optional buffers) sufficient quantities of each type of data for formation of an MPEG-2 compliant packet so that alternate packets contain normal digital video data with intervening packets containing robust digital video data. Other patterns of packets may also be employed (e.g., every third packet contains robust data, etc.).

[0022] The switched data is processed according to conventional VSB encoding (step 303), including randomizing, Reed Solomon encoding, interleaving and packet formatting, trellis interleaving and trellis encoding the data. Parity data is generated and inserted in packets containing normal digital video data (step 304) for backwards compatibility. The packets containing encoded digital video data are then processed in preparation for transmission using a standard VSB modulator (step 305). Such processing includes: bit-to-byte conversion and trellis deinterleaving; "main" deinterleaving; removal of a trailing portion of each packet sufficient to form an MPEG compliant packet (i.e., removing 20 bytes in the exemplary embodiment, to form a 188 byte packet after insertion of a sync byte); and derandomizing. As noted above, the bytes removed are parity in packets containing normal data and encoded digital video information (recovered by the Reed Solomon encoder on the transmitter side) in packets containing robust data. In addition, parameter signaling bits are inserted in the reserved bits of the field sync and MPEG sync bytes are inserted in the packets.

[0023] The processed packets are then forwarded to a standard VSB modulator implemented at a transmitter (step 306), and processed according to standard VSB modulation (step 307), including randomizing, Reed Solomon encoding (which recovers the robust data removed from each packet), interleaving and trellis encoding, then pilot insertion, VSB modulation and RF up-conversion. The process of steps 302-307 continues repetitively as long as digital video data remains to be transmitted, then becomes idle (step 308) when all normal and robust data has been transmitted.

[0024] The present invention allows normal and robust data to be multiplexed for backwards-compatible concurrent VSB transmission while implementing the enhancements at the studio (e.g. for a network news or other broadcast program) so that a standard VSB modulator at the transmitter (e.g., for a network affiliate station).

[0025] It is important to note that while the present invention has been described in the context of a fully functional system, those skilled in the art will appreciate that at least portions of the mechanism of the present invention are capable of being distributed in the form of a machine usable medium containing instructions in a variety of forms, and that the present invention applies equally regardless of the particular type of signal bearing medium utilized to actually carry out the distribution. Examples of machine usable mediums include: nonvolatile, hard-coded type mediums such as read only memories (ROMs) or erasable, electrically programmable read only memories (EEPROMs), recordable type mediums such as floppy disks, hard disk drives and compact disc read only memories (CD-ROMs) or digital versatile discs (DVDs), and transmission type mediums such as digital and analog communication links and frames or packets.

[0026] Although the present invention has been described in detail, those skilled in the art will understand that various changes, substitutions, variations, enhancements, nuances, gradations, lesser forms, alterations, revisions, improvements and knock-offs of the invention disclosed herein may be made without departing from the spirit and scope of the invention in its broadest form.